AIR INTAKE APPARATUS

This application is based on Japanese Patent Application No. 2003-078443, which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an air intake apparatus serving as a passageway for supplying the air to an engine, and particularly relates to an air intake apparatus in which noise is reduced at the time of intake.

2. Description of the Related Art

In an air intake apparatus of an engine, intake air introduced through an inlet is supplied to an engine body through an intake air passageway portion connecting the inlet with the engine body. An air intake duct continuing to the inlet is provided in the intake air passageway portion. In addition, various air intake members such as an air cleaner, an air cleaner hose, a throttle body and an intake manifold are generally disposed in the intake air passageway portion together with the air intake duct. These various air intake members also form a part of the intake air passageway portion.

Here, in the air intake apparatus, noise occurs in the air intake duct or the like at the time of intake. This noise leaks to the outside of the air intake apparatus through the

inlet, and is propagated to the inside of the vehicle cabin or to the outside of the vehicle cabin. Thus, various measures for reducing the intake noise have been hitherto developed.

As one of the measures for reducing the intake noise, it is known that an aperture is provided in a part of an air intake duct and covered with a porous member so as to form a permeable port (for example, Patent Document 1).

When the permeable port is provided in a part of the air intake duct as disclosed in Patent Document 1, the intake noise is reduced. The reason is conceived to be a synergistic effect among the following effects.

(1) Occurrence of acoustic waves caused by vibration of the intake air passageway portion is suppressed due to the damping effect caused by the elasticity of the porous member.

(2) The energy of the acoustic waves entering the pores of the porous member is weakened by the effect of the viscosity and heat conduction of the pores, and the pores themselves resonate with the fluctuation of the sound pressure so that the sound energy is attenuated.

(3) At least a part of the intake air passageway portion has a certain degree of air permeability so that occurrence of standing waves is suppressed.

On the other hand, the present applicant found that the intake noise was reduced more efficiently when the position where the permeable port was disposed in the air intake duct

was set in a specific position (for example, Patent Document 2).

That is, when the longitudinal center of the permeable port is disposed in a position of 1/4 of the whole length of the tube wall of the air intake duct from an end portion of the tube wall, the position of the permeable port can be set to overlap with an antinode of a resonant wave generated in the air intake duct. Thus, the size of the permeable port can be set to be small while the intake noise is reduced sufficiently.

Here, when the permeable port is provided in the position disclosed in Patent Document 2, the resonant noise of the air intake duct can be reduced. However, air intake members other than the air intake duct are disposed together in the air intake apparatus as described previously. Accordingly, noise is also generated due to the other air intake members. Thus, development of an air intake apparatus in which not only the resonant noise of an air intake duct but also the intake noise of the air intake apparatus as a whole can be reduced has been demanded.

[Patent Document 1]

JP-A-63-285257

[Patent Document 2]

JP-A-2001-336457

SUMMARY OF THE INVENTION

An object of the invention is to provide an air intake apparatus in which intake noise of the air intake apparatus as a whole can be reduced.

To solve the foregoing problems, according to the invention, there is provided an air intake apparatus having an intake air passageway portion which includes an air intake duct continuing to an inlet for introducing outside air, and which serves as an intake air path reaching an engine body, and a permeable port including an aperture provided in a part of the intake air passageway portion and for allowing the inside of the intake air passageway portion to communicate with the outside thereof, and a porous member covering the aperture, wherein the permeable port is provided in at least a part of a region between a central position of the whole length of the air intake duct and a central position of the whole length of the intake air passageway portion.

Fig. 1 shows a schematic path diagram of a typical air intake apparatus.

An inlet 101 is provided in an air intake apparatus 100. Intake air is introduced into the air intake apparatus 100 through the inlet 101. The intake air introduced into the air intake apparatus 100 makes its way to the intake air downstream side through an air intake duct 102. For example, when an air cleaner 103 is provided as shown in Fig. 1, the intake air goes through the air cleaner 103 (including a dirty-side 104, an

element 105 and a clean-side 106) and an air cleaner hose 107. Then, the intake air is introduced into a not-shown engine body through a throttle body 108 and an intake manifold 109. Here, the length ranging from the inlet 101 to the air intake duct 102 continuing to the inlet 101 is defined as whole length l_1 of the air intake duct 102, and the length ranging from the inlet 101 to the border with the engine body via the air intake duct 102 is defined as whole length l_2 of the intake air passageway portion.

In the air intake apparatus according to the invention, the permeable port is provided in at least a part of a region between the central position A of the whole length l_1 of the air intake duct and the central position B of the whole length l_2 of the air intake passageway portion.

Here, in the invention, for example, when the air intake duct has a curved or bent shape, the whole length of the air intake duct means the length following the curved or bent shape. Further, in the same manner, when the intake air passageway portion, for example, has a curved or bent shape, for example, when the air intake duct is connected to an air cleaner casing at an angle or when the air cleaner hose is connected to the intake manifold at an angle, the whole length of the intake air passageway portion means the center line length following the curved or bent shape.

The central position A of the whole length of the air

intake duct as shown in Fig. 1 is a position corresponding to an antinode of an odd harmonic of a resonant in the air intake duct. On the other hand, the central position B of the whole length of the intake air passageway portion is a position which corresponds to an antinode of a resonant of a standing wave in the intake air passageway as a whole and in which the sound pressure of a low frequency (about 50-120 Hz) is enhanced. Accordingly, when the permeable port is provided in at least a part of the region between the central position of the whole length of the air intake duct and the central position of the whole length of the intake air passageway portion, both the intake noise caused by the air intake duct and the intake noise caused by the intake air passageway portion as a whole can be reduced.

In addition, in the air intake apparatus according to the invention, it is preferable that the permeable port is provided in a position including at least one of the central position of the whole length of the air intake duct and the central position of the whole length of the intake air passageway portion. It is more preferable that the permeable port is provided in positions including at least the central position of the whole length of the air intake duct and the central position of the whole length of the intake air passageway portion.

BRIEF DESCRIPTION OF DRAWINGS

Fig. 1 is a schematic path diagram of a typical air intake apparatus;

Fig. 2 is a schematic path diagram of an air intake apparatus in a first embodiment of the invention;

Fig. 3 is a sectional view of an air intake duct of the air intake apparatus in the first embodiment of the invention, taken on line C-C' in Fig. 2;

Fig. 4 is a sectional view of another example of the air intake duct, taken on line C-C' in Fig. 2;

Fig. 5 is a sectional view of another example of the air intake duct, taken on line C-C' in Fig. 2;

Fig. 6 is a sectional view of another example of the air intake duct, taken on line C-C' in Fig. 2;

Fig. 7A is a schematic path diagram of an air intake apparatus in a second embodiment of the invention, and Fig. 7B is another schematic path diagram of an air intake apparatus in a second embodiment of the invention;

Fig. 8 is a schematic path diagram of an air intake apparatus in a third embodiment of the invention;

Fig. 9 is a schematic path diagram of an air intake apparatus in a fourth embodiment of the invention;

Fig. 10 is a schematic path diagram of an air intake apparatus in Comparative Example; and

Fig. 11 is a graph showing the result of an intake noise test.

DETAILED DESCRIPTION OF THE PREFFERED EMBODIMENTS

An air intake apparatus according to the invention has an intake air passageway portion which includes an air intake duct continuing to an inlet for introducing the outside air, and which serves as an intake air path reaching an engine body. In the invention, the intake air passageway portion may be provided with various air intake members selected and disposed suitably, as well as the air intake duct. The air intake members include a resonator, an air cleaner, an air cleaner hose, a throttle body, an intake manifold, etc. Incidentally, in the air intake apparatus according to the invention, intake noise is reduced as will be described later. It is therefore unnecessary to dispose a resonator, or it is sufficient to dispose a small-size resonator.

In the air intake apparatus according to the invention, an aperture is provided in a part of the intake air passageway portion. This aperture is provided to allow the inside of the intake air passageway portion to communicate with the outside thereof. The aperture serves as a release port for releasing intake air pulsation occurring inside the intake air passageway to the outside of the intake air passageway. In addition, the aperture also exerts an effect of suppressing the occurrence of standing waves. In addition, the aperture is covered with a porous member. Since the aperture is covered with the porous

member, foreign matters are prevented from invading the inside of the intake air passageway from the outside of the aperture through the aperture. In addition, the porous member also has a damping effect and an energy attenuation effect such that transmitted noise released to the outside of the aperture is reduced. In the invention, a permeable port is constituted by the aperture and the porous member.

Various kinds of materials including fiber, paper, foam and the like may be used for forming the porous member. It is particularly preferable to use non-woven fabric, woven fabric, knitted fabric, or the like, formed out of thermoplastic fiber. Thermoplastic resin fibrous non-woven fabric or the like can be formed easily by use of a method of hot press molding or the like. Therefore, even when the intake air passageway portion has a complicated shape and the aperture shape is curved following the intake air passageway portion, the shape of the porous member can be formed easily into a shape following the aperture shape so that the shape of the porous member can be adapted to the aperture shape easily. Incidentally, the whole of the non-woven fabric or the like may be formed out of thermoplastic resin fiber, or only a part of the non-woven fabric or the like may be formed out of thermoplastic resin fiber. For example, even non-woven fabric or the like formed out of non-thermoplastic fiber impregnated with thermoplastic resin binder can be formed by hot press molding or the like in the

same manner as the whole of the porous member is formed out of thermoplastic resin.

In addition, the porous member can be joined to the intake air passageway portion easily in a known method of hot welding, ultrasonic welding or the like. Further, the porous member can be molded integrally with the intake air passageway portion in a known insert molding method or the like so as to be joined thereto.

Here, when the permeability of the porous material is too high, acoustic waves in the intake air passageway portion permeate the aperture and the porous member and leak out to the outside. Thus, so-called transmitted noise increases. Therefore, in order to prevent the problem that the noise increases instead, it is desired that the permeability is set so that the flow rate of the air is not higher than 6,000 m^3/h per 1 m^2 at the time of a pressure difference of 98 Pa. Incidentally, the flow rate means the quantity of the air per unit time passing through a unit area of a specimen when the pressure difference between two chambers divided by the specimen is set at 98 Pa. The restriction of not higher than 6,000 m^3/h per unit area is, of course, a restriction in the case of the air having a pressure difference of 98 Pa. Not to say, the numerical value of the restriction of the flow rate will be changed if the pressure of the intake air is changed.

When the flow rate of the air per 1 m^2 at the time of

a pressure difference of 98 Pa exceeds 6,000 m^3/h, acoustic waves passing through the aperture and the non-woven fabric increases so that the transmitted noise increases. On the contrary, when the flow rate is zero, the effect of suppressing noise in a low frequency band of not higher than 200 Hz is weakened, but the effect of suppressing noise survives because acoustic waves abut against the pores of the porous member. Here, in order to make the flow rate of the porous member zero, a membranous skin layer may be formed on the surface of the porous member to be disposed on the external surface side of the intake air passageway portion. That is, when the pores of the porous member are exposed to the internal surface of the intake air passageway portion, the flow rate can be set at zero while the effect of the porous member derived from its pores is secured. Incidentally, it is preferable that the flow rate of the air in the porous member at the time of a pressure difference of 98 Pa is higher than zero and lower than 4,200 m^3/h, and it is particularly preferable that the flow rate is higher than zero and lower than 3,000 m^3/h.

In addition, the thickness or characteristic of the porous member may change due to aging, moisture penetration, or the like. In this event, the balance between the transmitted noise transmitted to the outside of the permeable port through the porous member and the intake noise radiated to the outside of the intake air passageway portion through the inlet may be lost

to change the performance in suppressing the intake noise.

It is therefore desired that the porous member has a predetermined function of weather resistance, water repellency or the like. Such a predetermined function can be added to the porous member by forming the porous member as a whole out of a material for exerting the predetermined function or by providing at least a part of the porous member with a functional layer formed out of a material for exerting the predetermined function.

In the invention, the permeable port is provided in at least a part of a region between the central position of the whole length of the air intake duct and the central position of the whole length of the intake air passageway portion.

As described previously, the central position of the whole length of the air intake duct is a position which corresponds to an antinode of an odd harmonic of a resonant in the air intake duct. On the other hand, the central position of the whole length of the intake air passageway portion is a position which corresponds to an antinode of a resonant of a standing wave in the intake air passageway portion as a whole and in which the sound pressure of a low frequency (about 50-120 Hz) is enhanced. Accordingly, when the permeable port exerting the effect is provided in at least a part of a region between the central position of the whole length of the air intake duct and the central position of the whole length of the intake air

passageway portion, both the intake noise caused by columnar resonance of the air intake duct and the intake noise caused by columnar resonance of the intake air passageway portion as a whole can be reduced.

As the area of a portion of the intake air passageway portion where the permeable port is disposed is larger, the effect of reducing the intake noise becomes larger. However, of the permeable port, the porous member covering the aperture is an expensive member. In order to reduce the material cost of the air intake apparatus, it is therefore preferable to provide the permeable port with a small configuration area. Accordingly, in the invention, the configuration area of the permeable port is set suitably in consideration of the manufacturing cost and the intake noise.

In addition, the permeable port may be provided continuously all over the region between the central position of the whole length of the air intake duct and the central position of the whole length of the intake air passageway portion in the direction of the whole length, or continuously in only a part of the region. Alternatively, the permeable port may be provided intermittently all over the region in the direction of the whole length, or intermittently in a part of the region. Here, a part of or all over the region in the direction of the whole length means a part of or all over the region only in the direction of the whole length of the intake air passageway

having a cubic shape. That is, the permeable port can be disposed cubically because the intake air passageway portion has a cubic shape. For example, when a plurality of permeable ports are provided and distributed at a plurality of places, the permeable ports can be laid out cubically in accordance with the shape of the intake air passageway portion. In this case, the cubically distributed positions of the permeable ports in the direction of the whole length are set between the central position of the whole length of the air intake duct and the central position of the whole length of the intake air passageway portion. Thus, the effect of reducing the intake noise can be obtained.

When the permeable port is provided continuously all over the region between the central position of the whole length of the air intake duct and the central position of the whole length of the intake air passageway portion in the direction of the whole length, the effect of reducing the intake noise can be enhanced. On the other hand, when the permeable port is provided continuously in only a part of the region or intermittently all over or only in a part of the region, the position where the permeable port is not provided can be formed as a join portion between respective air intake members or as a position for mounting another member thereon. Thus, the degree of freedom in designing the air intake members is increased. Further, when the permeable port is provided

closely to the central position of the whole length of the air intake duct, the intake noise chiefly caused by the air intake duct can be reduced. On the other hand, when the permeable port is provided closely to the central position of the whole length of the intake air passageway portion, the intake noise chiefly caused by the intake air passageway portion as a whole can be reduced.

In the invention, it is preferable that the permeable port is provided in at least the central position of the whole length of the air intake duct and the central position of the whole length of the intake air passageway portion. That is, when the permeable port is provided continuously or intermittently in a position or positions including both the central position of the whole length of the air intake duct and the central position of the whole length of the intake air passageway portion, the intake noise caused by columnar resonance of the air intake duct and the intake noise caused by columnar resonance of the intake air passageway portion as a whole can be reduced surely.

Incidentally, when an air cleaner is provided as a part of the intake air passageway portion, the permeable port may be provided on the intake air upstream side (so-called dirty side) of an element for cleaning the air or on the intake air downstream side (so-called clean side) of the element. When the permeable port is provided on the clean side, the air passing

through the porous member of the permeable port has been cleaned by the element. Thus, the life of the porous member can be extended. When the permeable port is provided on the dirty side, the air entering the intake air passageway portion through the permeable port is also cleaned by the element. Thus, the air supplied to the engine can be kept clean more surely.

Embodiments of the invention will be described below with reference to the accompanying drawings.

(First Embodiment)

An air intake apparatus in a first embodiment of the invention has a configuration of an air intake apparatus of a car, showing an example in which an air cleaner is disposed as a part of an intake air passageway portion. Fig. 2 shows a schematic path diagram of the air intake apparatus in the first embodiment.

According to an air intake apparatus 1 in the first embodiment, an air cleaner 3 is disposed as a part of an intake air passageway portion 2. Accordingly, in the air intake apparatus 1 in the first embodiment, intake air is introduced into an engine body in the following path. First, intake air introduced into the intake air passageway portion 2 through an inlet 5 passes through an air intake duct 6 and enters the air cleaner 3. The intake air goes through a dirty side 7, an element 8 and a clean side 10 in the air cleaner 3 in that order. Thus, the intake air passes through the air cleaner

3. The intake air passing through the air cleaner 3 enters an air cleaner hose 11 continuing to the air cleaner 3. Then, the intake air enters an intake manifold 13 through a throttle body 12. The air entering the intake manifold 13 is introduced into a not-shown engine body through a port 15 which is the border between the intake manifold 13 and the engine body. In this Example, the path between the inlet 5 and the port 15 is arranged as the intake air passageway portion 2.

According to the air intake apparatus 1 in the first embodiment, the length of the air intake duct 6 connecting the inlet 5 to the air cleaner 3 serves as the whole length l_1 of the air intake duct 6, and the length ranging from the same inlet 5 to the port 15 through the air intake duct 6, the air cleaner 3, the air cleaner hose 11, the throttle body 12 and the intake manifold 13 serves as the whole length l_2 of the intake air passageway portion 2.

According to the air intake apparatus 1 in the first embodiment, one permeable port 16 is provided all over the region between the central position A of the whole length l_1 of the air intake duct 6 and the central position B of the whole length l_2 of the intake air passageway portion 2 including the central position A of the whole length l_1 of the air intake duct 6 and the central position B of the whole length l_2 of the intake air passageway portion 2. Fig. 3 shows a sectional view of the air intake duct 6, taken on line C-C' in Fig. 2.

The permeable port 16 is constituted by an aperture 17 and a porous member 18. The aperture 17 is formed by continuously cutting the wall surface of the air intake duct 6 and the wall surface of the dirty side 7 of the air cleaner 3 in the intake air passageway portion 2. On the other hand, the porous member 18 is made from non-woven fabric (weight density 1,000 g/m^3, thickness 3.5 mm and flow rate 1,680 $m^3/h \cdot m^2$) made of fiber using PET as material. The permeable port 16 is formed by hot welding of the PET porous member 18 to the intake air passageway portion external surface side 20 of the aperture 17 formed in the resin wall surfaces of the air intake duct 6 and the dirty side 7 of the air cleaner 3. Although the permeable port 16 is formed into a shape shown in Fig. 3 in the first embodiment, the permeable port 16 may be formed as shown in Fig. 4. That is, each outer edge 19 of the aperture 17 of the intake air passageway portion 2 is formed to project outward from the intake air passageway portion 2, and the porous member 18 is welded to the projecting outer edge 19. Alternatively, the permeable port 16 may be formed as shown in Fig. 5. That is, an end portion 24 of each projecting outer edge 19 is made substantially parallel with the external surface of the intake air passageway portion 2, and the porous member 18 is welded to the end portion 24. Further, the permeable port 16 may be formed as shown in Fig. 6. That is, a porous member 18 formed into a predetermined shape in advance is used, and the intake air passageway portion 2 is

formed integrally with the porous member 18 by insert molding. Further, although the porous member 18 is welded by hot welding in this Example, for example, a method of ultrasonic welding or the like may be used.

According to the air intake apparatus 1 in the first embodiment, the permeable port 16 is provided between the central position A of the whole length of the air intake duct 6 and the central position B of the whole length of the intake air passageway portion 2. Accordingly, both the intake noise caused by the air intake duct 6 and the intake noise caused by the intake air passageway portion 2 can be reduced. Then, the permeable port 16 is provided in a position including both the central position A of the whole length of the air intake duct 6 and the central position B of the whole length of the intake air passageway portion 2. Accordingly, both the intake noise caused by the air intake duct and the intake noise caused by the intake air passageway portion can be reduced more surely.

(Second Embodiment)

An air intake apparatus in a second embodiment of the invention is the same as that in the first embodiment, except the number of permeable ports distributed and the positions where the permeable ports are distributed. Fig. 7A shows a schematic path diagram of an air intake apparatus 21 in the second embodiment.

In the air intake apparatus 21 in the second embodiment,

a permeable port 22 is divided into three, first to third permeable ports 23, 25 and 26, which are distributed at a distance from each other in the direction of the whole length. The first permeable port 23 is disposed in a predetermined position of an air intake duct 27, which is a position including the central position A of the whole length l_1 of the air intake duct 27. The second permeable port 25 is disposed in a predetermined position of a dirty side 31 of an air cleaner 30, which is a position including the central position B of the whole length l_2 of an intake air passageway portion 28. Further, the third permeable port 26 is disposed in a substantially central position between the positions where the first and second permeable ports 23 and 25 are disposed in the direction of the whole length, so that the third permeable port 26 spreads over the dirty side 31 of the air cleaner 30 and the air intake duct 27. In addition, the second and third permeable ports 25 and 26 are provided in cubically distributed positions different from each other. For example, the first and third permeable ports 23 and 26 can be provided in spirals as shown in Fig. 7B.

In the second embodiment, the first to third permeable ports 23, 25 and 26 are provided between the central position A of the whole length l_1 of the air intake duct 27 and the central position B of the whole length l_2 of the intake air passageway portion 28. Accordingly, in the same manner as in the first embodiment, both the intake noise caused by the air intake duct

and the intake noise caused by the intake air passageway portion can be suppressed. Then, since the permeable port 22 is divided and distributed, a space 32 between the first permeable port 23 and the third permeable port 26 or a space 33 between the second permeable port 25 and the third permeable port 26 may be formed as a join portion between the air cleaner 30 and the air intake duct 27 or as a mounting position for mounting another member thereon. Thus, the degree of freedom in designing the intake air passageway portion 28 can be enhanced.

(Third Embodiment)

An air intake apparatus in a third embodiment of the invention is the same as the air intake apparatus in the second embodiment, except that the permeable port is constituted by the first and second permeable ports. Fig. 8 shows a schematic path diagram of the air intake apparatus in the third embodiment.

In an air intake apparatus 35 in the third embodiment, a permeable port 36 is constituted by only first and second permeable ports 23 and 25 the same as those in the second embodiment. That is, in the air intake apparatus 35 in the third embodiment, the third permeable port 26 is removed from the air intake apparatus 21 in the second embodiment.

According to the air intake apparatus 35 in the third embodiment, the effect of reducing the intake noise is inferior to that in the air intake apparatus 21 in the second embodiment because the third permeable port 26 is absent. However, the

effect of reducing both the intake noise caused by an air intake duct 37 and the intake noise caused by an intake air passageway portion 38 can be obtained because the first permeable port 23 is disposed in a position including the central position A of the whole length l_1 of the air intake duct 37 and the second permeable port 25 is disposed in a position including the central position B of the whole length l_2 of the intake air passageway portion 38. Then, since the area where the permeable port 36 is disposed is reduced, the usage of the expensive porous member is reduced so that the manufacturing cost is reduced.

(Fourth Embodiment)

An air intake apparatus in a fourth embodiment of the invention is the same as the air intake apparatus in the second embodiment, except that the permeable port is constituted by only the second permeable port. Fig. 9 shows a schematic path diagram of the air intake apparatus in the fourth embodiment.

In an air intake apparatus 40 in the fourth embodiment, a permeable port 41 is constituted by only a second permeable port 25 the same as that in the second embodiment. That is, in the air intake apparatus 40 in the fourth embodiment, the first and third permeable ports 23 and 26 are removed from the air intake apparatus 21 in the second embodiment.

According to the air intake apparatus 40 in the fourth embodiment, the effect of reducing the intake noise is inferior to that in the air intake apparatus 21 in the second embodiment

because the first and third permeable ports 23 and 26 are absent. However, the effect of reducing the intake noise caused by an intake air passageway portion 42 can be obtained because the second permeable port 25 is disposed in a position including the central position B of the whole length l_2 of the intake air passageway portion 42. Then, since the area where the permeable port 41 is disposed is reduced, the usage of the expensive porous member is reduced so that the manufacturing cost is reduced.

(Comparative Example)

An air intake apparatus in Comparative Example is the same as the air intake apparatus in the first embodiment, except that a permeable port 43 is provided only in a substantially central position between the central position A of an air intake duct 45 and an inlet. Fig. 10 shows a schematic path diagram of the air intake apparatus in Comparative Example.

(Intake Noise Test)

The intake noises in the air intake apparatus in Embodiments 3 and 4 of the invention and Comparative Example and the air intake apparatus in the related art shown in Fig. 1 were calculated as sound pressure level for each frequency. The sound pressure level was calculated by BEM (Boundary Element Method) using SYSNOISE software and input data of each air intake apparatus. The data of each air intake apparatus included data of air intake member shapes including lengths, widths, volumes,

etc. of air intake members such as an air intake duct, an air cleaner and the like constituting the air intake apparatus, and data of the shape of a permeable port including the area of an aperture, the roughness of a porous member, etc. Incidentally, as for the vibration speed, it was assumed that the vibration speed of the air in a port position was constant (1 m/s). Fig. 11 shows a graph of the result.

In the air intake apparatus in Comparative Example having a permeable port in an air duct, the sound pressure level was reduced in an intermediate frequency band near 300 Hz and a high frequency band near 400 Hz in comparison with that in the air intake apparatus in the related art having no permeable port. In the air intake apparatus in the fourth embodiment having a permeable port in a position including the central position of the whole length l_2 of the intake air passageway portion, the sound pressure level was reduced in a low frequency band near 60 Hz in comparison with that in the air intake apparatus in the related art having no permeable port. Further, in the air intake apparatus in the third embodiment having permeable ports in positions including the central position of the whole length of the air intake duct and the central position of the whole length of the intake air passageway portion, the sound pressure level was further reduced all over the range from a low frequency band to a high frequency band in comparison with that in the air intake apparatus in the fourth embodiment, that

in the air intake apparatus in Comparative Example and that in the air intake apparatus in the related art. From these facts, it is understood that the peak value of the sound pressure level appearing near 300 Hz, that is, the intake noise caused by the air intake duct can be reduced by a permeable port provided in the central position of the whole length of the air intake duct. In addition, it is understood that the peak value of the sound pressure level appearing near 60 Hz, that is, the intake noise caused by the intake air passageway portion as a whole can be reduced by a permeable port provided in a position including the central position of the whole length of the intake air passageway portion.

As described above, according to an air intake apparatus according to the invention, both the intake noise caused by an air intake duct and the intake noise caused by an intake air passageway portion can be reduced so that the intake noise of the air intake apparatus as a whole can be reduced.